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(Continuation of Contributions from the Museum of Geology)

UNIVERSITY OF MICHIGAN

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DESCRIPTION OF A NEARLY COMPLETE SKELETON OF *OSTODOLEPIS BREVISPINATUS* WILLISTON

BY

E. C. CASE

UNIVERSITY OF MICHIGAN

ANN ARBOR

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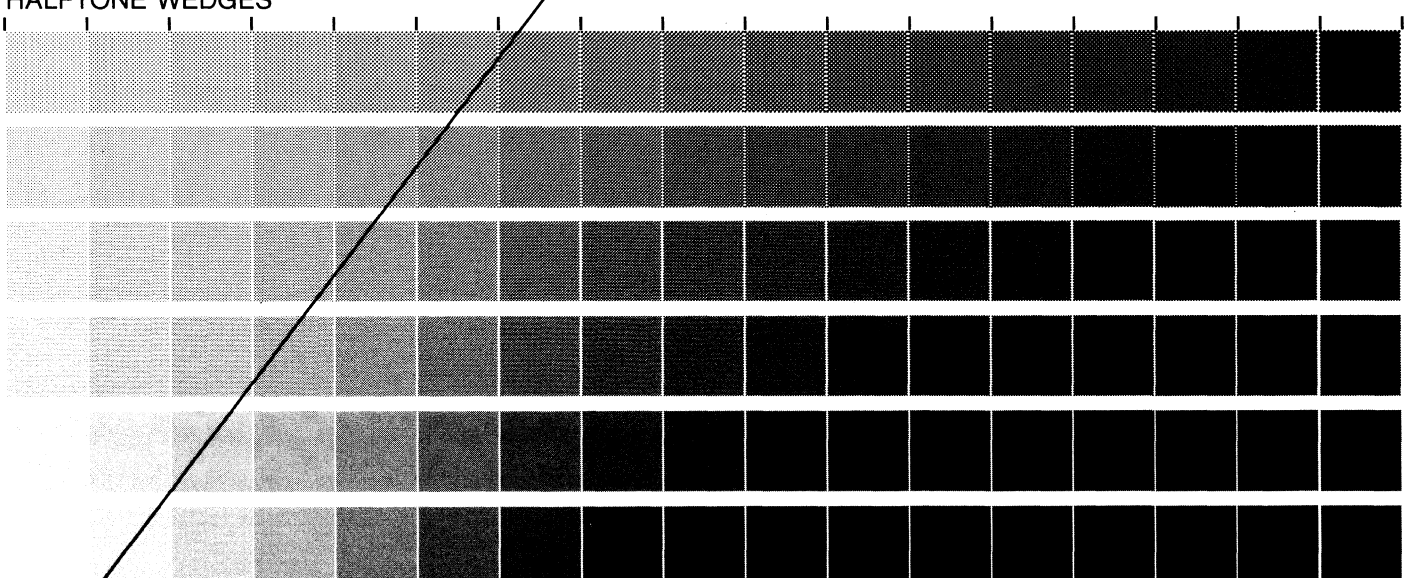

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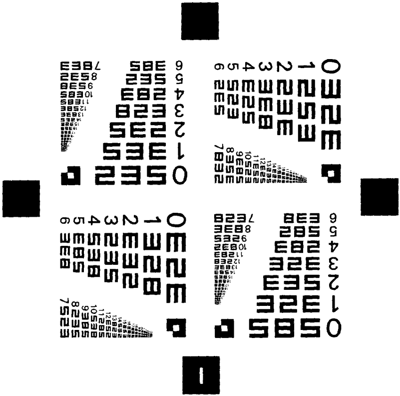

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CONTRIBUTIONS FROM THE MUSEUM OF PALEONTOLOGY

(Continuation of Contributions from the Museum of Geology)

UNIVERSITY OF MICHIGAN

Editor: EUGENE S. McCARTNEY

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DESCRIPTION OF A NEARLY COMPLETE SKELETON OF *OSTODOLEPIS BREVISPINATUS* WILLISTON

By E. C. CASE

IN 1913 Williston[1] published an account of a series of seven articulated vertebrae with the ribs in position and an associated mass of dermal scutes, contained in a block of red sandstone from the Clear Fork, Permian, beds of Coffee Creek, Willbarger County, Texas. To this specimen he gave the name *Ostodolepis brevispinatus.*

The vertebrae were described and figured as being as broad as long, with short, stout diapophyses located near the anterior part of the neural arch, directed forward and a little backward and with the free oval end a little cupped; the centra notochordal with the lower surface gently concave longitudinally and transversely; the neural arches low and flattened, broad from side to side and with a small, almost vestigial tuberculiform neural spine; the zygapophyses broad and flat with the articular faces looking almost directly up and down; the ribs with rather prominent and short tuberculum and capitulum, the latter attached intervertebrally and near the ends of a very slender intercentrum.

The scutes were described as about 8 mm. long and nearly as broad, about as thick as writing paper, the outer surface showing under the hand lens a very distinct series of raised lines quite concentric with the free margin and quite like the "cycloid scales of a fish."

Later Williston[2] suggested "that the name *Ostodolepis* may

[1] Williston, S. W., "*Ostodolepis brevispinatus,* a New Reptile from the Permian of Texas," *Journal of Geology,* Vol. XXI, No. 4, 1913.

[2] Williston, S. W., "The Osteology of Some American Permian Vertebrates," *Contributions from Walker Museum,* Vol. I, No. 9, p. 175, 1916.

be retained as a probable though as yet uncertain synonym of *Pantylus.*"

As will be seen from the following account the vertebrae and scutes of the specimen here described, number 11,156 of the Museum of Paleontology of the University of Michigan, correspond very closely with those of the type specimen of *Ostodolepis brevispinatus,* and the specimen is referred to that genus and species. It was obtained from the University of Chicago, about 1912, in exchange, and in all probability came from the same locality and geological horizon as the type specimen. It was enclosed in a nodule of hard calcareous red sandstone and seemed so impossible of development that it was long allowed to lie untouched. A fortunate exploration with a fine chisel revealed that the specimen could be cleaned and, though it has cost the author more than a month's time chiseling with a needle under a binocular microscope, the results seem worth the effort.

As shown in Plate I, Figure 1, the animal collapsed in a bent position after death, with the head, the right forearm and the anterior vertebrae in the natural relations. The posterior part of the vertebral column and the posterior limbs were disturbed and some portions were lost. The skull was fortunately fractured longitudinally almost in the median line, and transversely just anterior to the orbits. There has been but very slight distortion of the skull or other parts of the skeleton.

Seen from above (Plate I, Fig. 2), the outline of the skull is a regular triangle strongly suggestive of that of *Captorhinus;* the greatest peculiarity is the lack of a pineal foramen. Seen from below (Plate I, Fig. 3) the short, powerful jaws, the long conical teeth, the long and broad parasphenoid rostrum, the relatively very large interpterygoid space and the broad articular process of the pterygoid bones are distinctly amphibian. Seen from the side (Plate II, Fig. I), the elevated posterior region of the skull, the cutting away of the lower border of the temporal region, the flat and projecting rostrum of the nose, and the large orbits are evidence of a systematic position remote from *Captorhinus* or any other known cotylosaur. This assemblage of seemingly irreconcilable characters is increased by those revealed in the fractured sections of the skull. As explained below, it seems certain that the upturning of the anterior end of the nose is due to a slight distortion, but the flattening and extension of the rostrum are not explainable by any theory of distortion or compression. Many apparent anomalies, including the absence of the pineal foramen, the peculiar proportions and relations of the bones of the cranial region and the presence of a large cranial cavity directly above the true brain cavity, may be reconciled with more normal structures on the assumption that they are the result of the elevation of the posterior portion of the skull.

The surface of the bones shows a very fine pitting or sculpture not resembling the linear sculpture of *Captorhinus* and not approaching in degree of coarseness the sculpture of many other cotylosaurs.

As with every other large group in which many forms have been placed, there is a tendency to split up the Cotylosauria, but for the present this form is retained in that Order, necessarily in a new family, the Ostodolepidae, containing the single aberrant genus *Ostodolepis*.

THE CRANIAL REGION

Basioccipital. — The occipital condyle is apparently formed largely by the basioccipital. The condition of the specimen is such that the amount played by the exoccipitals in the condyle cannot be exactly determined, but it is certain that it was a relatively small part, as the basioccipital forms the floor of the foramen magnum. The basioccipital portion of the articular face of the condyle is peculiar in that the upper half is convex and the lower half concave (Text Fig. 1). The concave portion may be interpreted as the rudimentary continuation of the notochord, but, as shown in the longitudinal section (Text Fig. 2), is very shallow and relatively lower down than in most of the Permian and Triassic reptiles. The basioccipital and the exoccipital are separated by a considerable space on one side and, apparently, by an equally large space on the other side. This separation has evidently taken place along the line of the suture.

The anterior half of the lower surface of the basioccipital is underlain by the parasphenoid which terminates in an abrupt shelf, the tubera basioccipitalia. Posterior to this shelf the lower surface is nearly flat except for a shallow groove, and is sharply deflected at the posterior end to form the lower edge of the condyle. The upper surface has a process rising to the lower edge of the very short canal of the foramen magnum; indeed, it may be said that there is no canal, the foramen being formed by thin edges of bone. The floor of the brain cavity is decidedly below the lower edge of the foramen magnum; it is smooth and the basioccipital portion terminates anteriorly in a strong suture with coarse interdigitations where it unites with the basisphenoid. In the longitudinal fracture this suture can be traced between the basioccipital and the parasphenoid to the tubera.

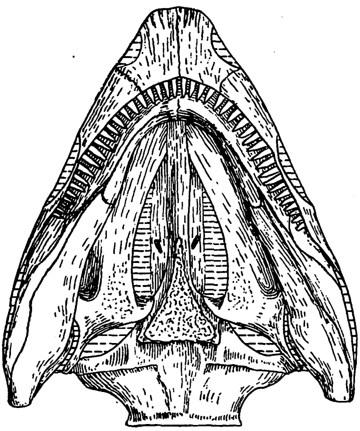

FIG. 1. Lower surface of the skull. × 1

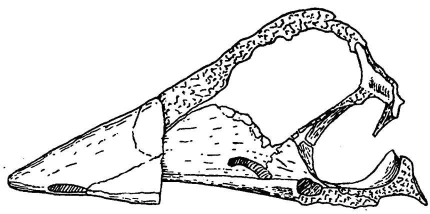

FIG. 2. Longitudinal section of the skull. × 1

The median portion of the floor of the brain cavity is somewhat higher than the sides, but the outer edges turn upward slightly, forming a shallow channel on either side. This upturning is most marked at the posterior end where the basioccipital joins the exoccipital and the otic bones. There are apparently two pairs of foramina in the floor of the brain cavity, a pair just anterior to the basioccipital-basisphenoid suture, which probably transmitted the sixth pair of cranial nerves, and a pair near the posterior end.

Basisphenoid and parasphenoid. — These bones are indistinguishably fused in the specimen, but the large development of the parasphenoid rostrum shows the persistence of that bone. The combined bones reach from the most anterior point visible, the anterior edge of the mandibular symphasis, to the middle of the lower surface of the basioccipital. The rostrum of the parasphenoid is a broad bar, hardly diminishing in breadth in its anterior portion. The anterior half is flattened below, but the posterior half is drawn down into a thin ridge. Posterior to the basipterygoid processes the bone widens and sends flanges outward as far as the middle of the length of the paroccipital process, much farther than the basioccipital. The outer edges of the flanges are closely adjacent to the lower edges of the opisthotics, but not in contact with them. The basipterygoid processes, which rise from the basisphenoidal portion of the bone, are strong and stand out at right angles, terminating in articular faces for the basisphenoidal processes of the pterygoids.

On the lower surface there is a triangular, elevated patch of rugose bone beginning anterior to the basipterygoid processes and extending back as far as the tubera. This is exactly the position occupied by a cluster of teeth in some of the amphibians, but there are no teeth present. Examination at a magnification of somewhat over 100 diameters reveals only a coarse, almost spongy surface, with the reticulations approaching a vermiculate character in some places. A similar appearance, but less pronounced, occurs on the adjacent portions of the pterygoids. Anterior to this patch the parasphenoid supports the ethmoidal elements.

The longitudinal fracture of the skull passes through the basioccipital and through the basisphenoid-parasphenoid as far forward as the middle of the rugose patch and a little to the left of the midline; anterior to this it passes entirely to the left of the parasphenoid rostrum so that the ethmoidal element of the left side is preserved partly on one of the pieces and partly on the other. This fortunate fracture permits an examination of the cranial cavities.

Just anterior to the basioccipital-basisphenoidal suture there is a strong rising process on either side of the basisphenoid, inclined slightly forward and outward. The bone is perforated at the base of each process by a large foramen which extends outward into the basipterygoid process and finds exit in the normal reptilian position just posterior to the basipterygoid process. The canals from either side meet and open into the brain cavity by a common foramen between the rising processes. These are evidently the canals and openings for the external carotid arteries. The floor of the brain cavity is slightly depressed at this point, forming a feeble sella turcia. The anterior edges of the rising processes are in articulation by coarse sutures with the posterior edges of the ethmoidal elements. The posterior portion of the upper edge of each process is in contact, or nearly so, with the plates described below as extending forward from the supraoccipital.

Epipterygoid. — Just outside the rising process of the basisphenoid there is a second rising element, based on both the basisphenoid and the pterygoid, which is evidently the epipterygoid. It is very thin, with nearly parallel anterior and posterior edges and in the specimen there are no notches at the upper end indicating the passage of nerves or vessels.

THE WALLS OF THE BRAIN CAVITY

The make-up of the walls of the brain cavity is at first very puzzling, but if, as suggested above, the elevation of the posterior portion of the skull is taken into account, the various elements may be brought into normal relationships. Beginning at the anterior end of the cavity, the rising process of the basisphenoid which articulates with the ethmoidal element is normal and understandable. The epipterygoid is normal in position and relations. There remain to be accounted for the proötic, epiotic and laterosphenoid (alisphenoid + orbitosphenoid). This complex should be continuous with the opisthotic, reaching upward to touch the parietal and perhaps, the supraoccipital, with the laterosphenoid portion touching the rising process of the basisphenoid, enclosing between them the large foramen for the fifth cranial nerve.

In the specimen there is a pair of plates, convex upward, extending forward from the supraoccipital and dividing the brain cavity from a larger one above it (see Plate II, Figs. 3 a and 3 b, and Text Fig. 2). The plates are united posteriorly, but are separated anteriorly, each lateral portion extending forward and downward until it comes in contact, or very nearly so, with the process from the basisphenoid. On the left side of the fracture the separation is by a very small space and on the right side they seem to be continuous by small fractured bits of bone in the matrix. On the right side the lower portion of the plate is marked by a sharp, deep, relatively large notch, evidently an imperfect foramen. The most careful examination shows these plates to be in undisturbed position and fused, no suture detectable, with the supraoccipital.

The assumption that the posterior portion of these plates is the epiotics and proötics is the most plausible. In most reptiles the epiotics and laterosphenoids extend upward to the under surface of the roof of the skull; the epiotic is attached to, or very near to, the supraoccipital. The elevation of the posterior portion of the roof of the skull in *Ostodolepis* would conceivably leave these elements in their natural relation to the brain, with the only possible attachment to the supraoccipital. By careful checking on the specimen it can be seen that the lower edge of the plate, epiotic and proötic portions, is separated by a very narrow space from the upper edge of the opisthotic, a space which could have been filled with cartilage or could be accounted for by the slight spreading of the skull indicated in the separation of the exoccipital from the basioccipital. The anterior portion of the plate, the laterosphenoid portion, comes into close association with the basisphenoid process. The notch described above as possibly an incomplete opening is on the posterior edge of the plate and cannot, therefore be the foramen for the fifth cranial nerve. Although the bone seems unbroken and the edges of the notch complete, it is possible that the notch is a partial section of the anterior semicircular canal of the inner ear.

THE LOWER SURFACE OF THE SKULL

(Plate I, Fig. 3, and Text Fig. 1)

Pterygoids. — These have the usual tripartite form with palatine, quadrate and external processes. The interpterygoid space is large and this, with the strong parasphenoid rostrum, is one of the strikingly amphibian characters of *Ostodolepis*. The general form of the bone is shown in Fig. 1. The palatine process extends forward as a broad, nearly flat plate with a decided rugose surface opposite the basisphenoid process. The inner edge is smooth and regular, slanting inward to touch the parasphenoid rostrum about opposite the anterior edge of the orbit. Posteriorly this edge is continued upon the lower surface of the bone leaving a notch between it and the basisphenoid process. The outer edge joins the palatine by a rather coarse suture. Because of the condition of the specimen, the presence of the hyoids (?), and the closed lower jaw, it is impossible to observe a distinct ectopterygoid, but the outer edge of the pterygoid rises and then turns sharply downward, again leaving a deep groove anterior to a point opposite the basisphenoid process. It is possible, even probable, that the outer, descending, wall of the groove is the ectopterygoid.

The process for the basisphenoid is broad with a smooth articular surface. It is distinctly articulated to the basisphenoid rather than the parasphenoid, a reptilian character. Immediately posterior to the process the quadrate process turns to the vertical position and rises nearly to the roof of the skull in the temporal region. The posterior end of this process reaches to and wraps around the posterior face of the quadrate. The lower edge is separated from the outer flange of the parasphenoid by an oval space. The posterior portion of the lower edge is slightly convex and concentric with the inner edge of the lower jaw just anterior to the articular region.

Parasphenoid. — It is impossible in the condition of the specimen to determine the relation of the anterior end of the parasphenoid to the adjacent bones. The inner edges of the palatine processes of the pterygoids touch the sides of the rostrum at points on a line with the anterior edges of the orbits.

Ethmoidal plates. — The paired ethmoidal plates rise from the outer edges of the parasphenoid rostrum, separated from it by distinct sutures, and curve outward enclosing a large cavity in the anterior portion of the skull. The lower portion of the posterior edge of each plate is joined by suture to the lower part of the anterior edge of the rising process of the basisphenoid, but the upper part curves forward leaving a space between the upper parts of the two elements. The plates reach to the roof of the skull a little posterior to the posterior edge of the orbit. The outline of the cavity enclosed and the relation of the plates to the parasphenoid and other bones are shown in the transverse fracture of the skull just anterior to the orbits (see Fig. 3). The anterior termination cannot be determined. Each plate is perforated obliquely by a foramen which originates on the inner side at a point just opposite the apex of the rugose patch on the lower surface of the parasphenoid and passes outward and forward; these foramina evidently transmitted the second pair of cranial nerves, and other nerves and vessels, to the eyeball.

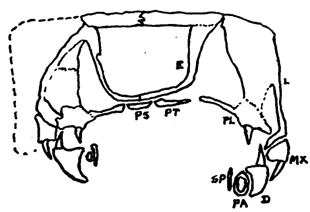

FIG. 3. Transverse section of the skull. The left side a little anterior to the right side, as the section was taken from a fracture surface. E, ethmoidal plate; PS, parasphenoid; PT, pterygoid; PL, palatine; L, lachrymal; MX, maxillary; SP, splenial; PA, prearticular; D, dentary. × 1.3

Prevomers (?). — These cannot be made out as the region is covered by the hyoid and the symphasis of the mandible.

Palatines. — The pterygoids occupy the greater visible portion of the palatal surface, but some portion of the palatines can be made out from this surface and from the transverse fracture. Excavation on the right side revealed a row of strong teeth on the outer edge of the palatine. These begin at the posterior end of the bone and five are shown in series behind the transverse fracture. All are stout and conical, with a narrow pulp cavity extending almost to the tip, as in the maxillary teeth. A tooth of nearly equal size is shown on the left side in the piece of the skull anterior to the fracture; this is so far anterior to the most anterior tooth shown on the right side as to account for three more teeth, making at least eight in all. The relation of the palatine to the other bones is shown in Fig. 3, as drawn from the surface of the transverse fracture. The palatine joins the maxillary and lachrymal on the outer side. Its inner edge is in contact with the pterygoid. Its outer edge has a strong buttress which affords attachment for the row of teeth.

Ectopterygoid. — This bone is not visible and its presence cannot be demonstrated, but its probable presence is suggested in the description of the pterygoid.

Hyoids (?). — As shown in Plate I, Figure 3, there are two pairs of long, slender bones lying on the palatine surface somewhat symmetrically. These are thin transversely and stand on edge in the specimen. Their ends show no structure. It was at first supposed that they were displaced ribs or elements, splenial or otherwise, loosened from the inner surface of the jaw. Complete examination revealed the impossibility of these assumptions, except that the anterior one on the left side may be the splenial. They resemble in form and position the long hyoids of some reptiles and can be identified only as such elements. There was no trace of a median element unless it be a small fragment of unrecognizable form found at the anterior end of the first pair. This small bit of bone suggested by its form that it was part of some crushed phalanges; it was necessarily removed.

THE POSTERIOR FACE OF THE SKULL

(Plate II, Fig. 2 and Text Fig. 4)

The outline of the bones of the posterior face of the skull seems at first impossible, but when considered in relation to the other peculiarities of the skull they may be brought into normal adjustment. The elevation of the posterior portion of the skull above the basis cranium resulted in certain changes in the proportions of the various bones that obscure their essentially normal relations. As yet unexplained are the absence of the pineal foramen and the large cavity above the true brain cavity. These are, in all probability, closely related. As the brain

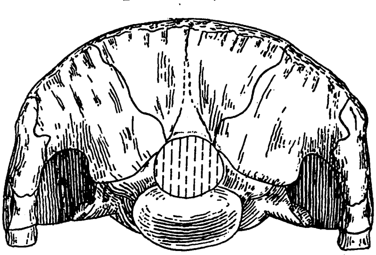

FIG. 4. Posterior surface of the skull. × 1

could not have extended above the otic and sphenoidal elements, the space above must have been in part empty or occupied by a large amount of tissue of some sort. The epiphysis and related structures probably passed upward in the space formed by the separation of the anterior ends of the otic and laterosphenoid plates, and were lost in the space or tissue above, never reaching the surface of the skull.

The elevation of the posterior end of the skull is accomplished by a uniform rise in the upper surface and a large development of the bones of the posterior surface, which lies at an angle of 100° to 105° to the plane of the roof. A close examination of the region shows that the portion immediately above the foramen magnum has been pushed slightly inward and is overlapped by the bones on either side. The depressed area is the supraoccipital. As shown in Figure 4, the dermsupraoccipitals are very long, coming down to contact with the exoccipitals. No suture or possible separation of the tabulare from the supratemporals can be detected; if such a separation was present, it must have been in the groove which marks the change from the posterior face of the skull to the upper surface. On the left side there is a fracture in the groove which might be interpreted as a fracture along the line of a suture; on the right side, where the other sutures are very evident, the bone is smooth and absolutely continuous. If the double character of the bone is assumed, the tabular is in contact with the exoccipital either by merely overlapping the suture between the basioccipital and the exoccipital, or by a direct overlapping suture with the exoccipital. Impossible as this may seem at first, it is not essentially different from the relations which occur in the stegocephalians and the most primitive reptiles where the exoccipital sends a process upward and touches the tabular. The tabular occupies its usual position on the mesial side of the otic notch. The posttemporal fenestra is not at first apparent because it is nearly closed by the great quadrate process of the pterygoid, but slight excavation reveals the opening into the space beneath the temporal roof.

If the cavity above the brain cavity is a separate thing, as seems certain, the question arises whether it is simply the continuation of the space beneath the temporal roof, or whether it is a distinct cavity. If the latter, what would form its lateral walls? It seems impossible that it can be a continuum of the temporal cavities; there must have been some septum, either single or double, extending from the surface of the epiotics to the roof of the skull. The cavity was excavated on the right side with the greatest care to a point well beyond the median line, but no trace of a bony septum nor any fragments that might be the remnants of such a septum were detected. If there was a septum, it must have been membranous or cartilaginous. The closest analogy to the condition is found in the turtles, in which the supraoccipital extends far forward and sends a median process to the roof. This median process joins the descending plates of the parietals in front, which are in the position of the epipterygoids, and part of the ethmoidal plates of this specimen. The supraoccipital of the turtles forms a good portion of the posterior part of the roof of the brain case and unites by complete anchylosis with the epiotic. Anterior to the supraoccipital the cranial cavity rises to the roof formed by the parietals. So far the analogy is good, but in this specimen there was no median bony septum dividing the space above the brain cavity. A cartilaginous or membranous septum in this position is unknown to the author, in any recent or fossil form.

The detailed description of the bones of the posterior face of the skull makes the apparently abnormal, but essentially normal, proportions and relations even more obvious.

Exoccipitals. — On the sides of the foramen magnum there is a pair of collar-like bones which touch the tabulare (+ supratemporals) and the dermsupraoccipitals; they are separated above by the supraoccipital. Traced laterally, the bone of the right side continues into a prominent condylar portion with a concave posterior face; this portion is apparently separated by a considerable space from the basioccipital below. The separation leads to the supposition that the whole exoccipital has been rotated inward on the upper surface, bringing the collar-like portion nearer to the median line and increasing the apparent width of the occipital condyle. As the collar-like portions of the exoccipitals are in similar positions on the two sides of foramen magnum, it is probable that the bones have been separated on the lower surface only. In the restoration the exoccipitals have been brought closer together on the lower side to reduce the size of the condyle and to bring it into consonance with the suggestion of the atlas. On the side of the condylar porton there is a large foramen for the exit of the last pair of cranial nerves. Just anterior to the foramen is the suture for the opisthotic.

Supraoccipitals. — The supraoccipital appears on the posterior surface in a small triangular area with the lower edge clearly showing the upper edge of the foramen magnum. The extent of the supraoccipital visible on the surface is somewhat doubtful. As stated above, it is overlapped on either side by the dermsupraoccipitals, but whether it originally extended to the top of the skull or only part way, is uncertain. On the fractured surface it can be traced to the roof of the skull beneath the dermsupraoccipitals. From the anterior face of the exposed portion rise the horizontal plates which divide the cavity of the skull; the fracture is through the place of origin of the plates and shows definitely that they are fused with the supraoccipital without any trace of a suture.

Dermsupraoccipitals. — As shown in Figure 4, the dermsupraoccipitals are large plates standing vertically in the posterior surface of the skull. In the specimen they apparently meet in the median line above the supraoccipital and join the tabulare laterally by suture. They meet the parietals above and the exoccipitals below. As in all the bones of the posterior surface, the surface is smooth with no indication of sculpture.

Tabulare and supratemporals. — As mentioned above, these two bones are indistinguishably united; the portion on the posterior face must be very largely, if not entirely, the tabular part, for this portion forms the inner edge of the otic notch.

Squamosals. — The posterior surface of the squamosal wraps around the quadrate covering all of it except the articular end. The lower part of the bone becomes very thin and terminates as a mere scale on the quadrate.

Quadrates. — Only the lower portion of the quadrate is visible.

It is covered mesially by the quadrate process of the pterygoid, posteriorly by the squamosal and externally by the quadratojugal. The quadrate foramen is about opposite the lower end of the squamosal. Unfortunately the quadrate is so far covered that little more than the broad articular end can be made out.

Quadratojugals. — The quadratojugal is visible only as a thin line from the posterior surface; its position is indicated by the quadrate foramen. Anteriorly it terminated very quickly as a sharp point against the lower edge of the squamosal, leaving quite a space between it and the posterior end of the jugal.

Opisthotics. — The opisthotic is in the normal reptilian position with the paroccipital process extending outward at a right angle to the basis cranium and terminating against the quadrate with a beveled facet on the anterior face of the extremity. The suture for union with the exoccipital is clearly apparent, being accentuated by a slight separation. The articulation with the epiotic and proötic is obscured by the deep implantation in the skull. Just below the origin of the paroccipital process is the narrow opening of the foramen ovale and just above the process is a pit of considerable size with an exceedingly thin scale of bone forming its bottom. Exploration of the inner side resulted in the perforation of the scale by the needle revealing its tenuous character. The pit may be entirely accidental owing to the thinness of the bone.

Stapes (?). — No stapes was found in the specimen, but considering the development of the opisthotic and its position, the stapes must have been an extremely delicate rod, easily displaced or destroyed.

THE UPPER AND LATERAL SURFACES OF THE SKULL

(Plate I, Fig. 2, Plate II, Fig. 1, and Text Figs. 5–6)

The outline of the various bones, as definitely as they can be determined, is shown in Figures 5–6. The probable course of such sutures as cannot be made out from one side or the other is shown in dotted lines. The skull has been but slightly distorted and no parts have been displaced, but there are a multitude of minute fractures which in places render it difficult to follow the sutures exactly. The slight distortion of the skull and the undistorted condition of the bones of the rest of the skeleton are very significant in the interpretation of the anterior end of the nose.

As shown in Plate II, Figure 1, the anterior end of the nose is turned slightly upward. That this is due to distortion is evident from the angular break shown on the surface, but the distortion is not sufficient to account for the flattening of the rostrum and the consequent sturgeon-like appearance from the side and from below. The general profile is much like that of the insectivore, *Necrolestes,* from the Santa Cruz beds of Patagonia. It was naturally assumed at first that the nose was rounded and elevated, as in *Captorhinus,* and had been reduced to its present form by crushing, but, as just stated, there is no evidence of such action in any other part of the skeleton. There is no lateral bulging of the rostrum and the lower surface is perfectly flat. The assumed original form was modeled in plastic clay and compressed to the form of the specimen. It was found that it could be reproduced only by a combined pressure and forward pull; such an application of forces was impossible in the specimen. The flat lower face of the rostrum could not have been formed by compression against any other element because it lay free in the matrix. Around the edge of the rostrum there is a break filled by matrix which might have been formed by compression, but it is not continuous and the edges of the bone on either side do not overlap. The elongate oval form of the external nares might be taken as evidence of compression, but their edges are complete and rounded, with little or no evidence of fracture or displacement. This portion of the skull has been discussed with one skilled in mechanics who was unable to see how compression and fracture could have produced the condition found. It has been discussed with a skilled preparateur who is convinced that the condition is natural, and with several friends familiar with osteology, all of whom consider the condition natural. However it may be, the specimen is described as it is. Accordingly, as the peripheral break is interpreted as a separation along a suture or an accidental fracture, the make-up of the rostrum may be interpreted in one or the other of two ways. Either the nasals form the entire upper surface of the rostrum and the premaxillaries the entire lower surface, or the nasals terminate at the point of upturning and the premaxillaries form the tip of the nose and the lower surface. In support of the second possibility there is a fracture at the line of upbending on the left side which might be along the line of a suture and there are certain indications on the right side which might indicate that the upbending took place along the nasal-premaxillary suture. In opposition to this idea the upper edge of the external narial opening of the right side is complete with the exception of two very straight lines which are evidently the lines of fracture without displacement. The first supposition seems the most plausible and is supported by the complete edges of the narial openings and the nature of the peripheral parting which, as shown above, is much more like a suture than a fracture. According to this interpretation, the rounded upper surface is formed entirely by the nasals and the flat lower surface entirely by the premaxillaries. Both surfaces show the same type of sculpture. The oval nares are almost entirely enclosed by the nasals and premaxillaries, the lachrymals and maxillaries taking only a small part in the posterior edge.

Premaxillaries. — The alveolar edge of the left premaxillary is injured, but that of the right premaxillary carries six imperfect teeth of the same form as the maxillary teeth and not larger than the largest of the maxillary series. These teeth lie almost horizontally in the specimen and give the strongest evidence for the crushing of the rostrum, for if they were as long as the longest of the maxillary series they would have interfered with the motion of the lower jaw. It seems certain that they have been bent from an oblique to a horizontal position.

Nasals. — The posterior and lateral outlines of the nasals are clearly shown. Each bone joins the frontal, prefrontal and lachrymal of its side and the nasal of the opposite side, and forms the upper border of the narial opening.

Septomaxillaries (?). — Within the orifice of the right narial opening there is a small bit of bone which might be regarded as a septomaxillary, but might equally well be regarded as a bit of the premaxillary detached from position. The point is in doubt.

Lachrymals. — The lachrymals are long and rather narrow, extending in the very primitive position from the orbit to the nares. Each bone forms the greater part of the anterior border of the corresponding orbit and, as seen in the transverse fracture, sends a wall inward toward the median line which partially cuts off the orbit from the cavity of the skull anterior to it. No trace of a lachrymal foramen can be found, though the condition of the specimen is such that the author would expect such a foramen to be visible if present.

Prefrontals, postfrontals and frontals. — The shape and relations of these bones are sufficiently well indicated in Figure 5. The noticeable irregularity of the median suture and the asymmetry of the bones are common amphibian characters.

Maxillaries. — The maxillary just touches the posterior lower corner of the narial opening and forms the lower border of the orbit; it joins the jugal by a horizontal suture behind the orbit and just on a level with its lower edge. The suture between it and the premaxillary, visible only on the lower surface, runs inward and backward from the posterior edge of the narial opening. The maxillary is narrow vertically and carries long, simple, conical teeth set in very shallow sockets practically throughout its length. Seventeen teeth can be counted on the left side and sixteen on the right. Most of the teeth are seen in longitudinal section, for their substance was softer than the matrix and in cleaning the surface came off with the scale. They all show a narrow pulp cavity reaching nearly to the apex and of nearly equal diameter throughout. The teeth are longest directly under the orbit and decrease both anteriorly and posteriorly. They are all straight with no posterior curvature and with no cutting edge. Examination of the broken surface under a

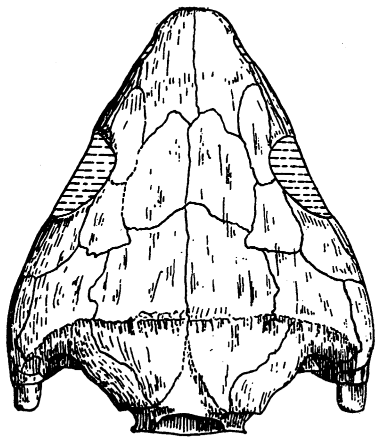

Fig. 5. Upper surface of the skull. $\times 1$

magnification of more than a hundred diameters shows no radial or other infolding of the substance. All the teeth, on both sides, are inclined inward, but not sufficiently to interfere with the movement of the lower jaw. The inclination is normal and passes into the horizontal position of the premaxillary without sudden change, a character which argues for the natural position of the latter.

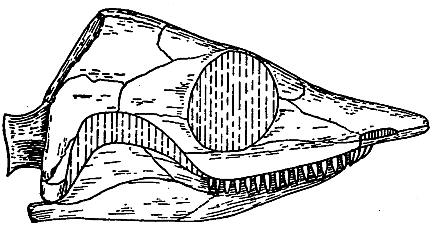

FIG. 6. Right side of the skull. The upturning of the nose corrected. × 1.

Jugals. — The jugal is hardly visible from the upper surface, but if the orbits were empty it would appear as a thin bar forming the posterior half of the lower border. From the side it is more evident, articulating with the maxillary as described and with the postorbital above. It does not reach back as far as the quadratojugal, leaving a space in which the postorbital and the squamosal form a part of the lower edge of the temporal region.

THE LOWER JAW

(Text Figs. 7a–7b)

The lower jaw is hidden partly by the complete closure and partly by the matrix at the posterior end, but most of the elements can be made out. The teeth are completely hidden, but the transverse fracture reveals that there was but a single row, similar in form to the maxillary teeth.

Surangulars. — The surangular rises sharply from the posterior end and forms a plate fitting into the space left by the cutting out of the lower edge of the temporal region.

Angulars. — The angular forms the lower part of the posterior end of the jaw and laps over slightly on the inner side below. Anteriorly it is wedged in between the coronoid, splenial and dentary.

Coronoids. — The coronoid is a sickle-shaped bone which forms the anterior half of the elevation of the posterior portion of the jaw and joins the angular, surangular and dentary. Because of the condition of the specimen it is impossible to say whether there is more than one coronoid, but apparently there is but one and it bears no teeth.

Articulars. — The articulars are largely concealed by the quadrates with which they are in close articulation and nothing can be made out except the presence of a distinct postarticular process.

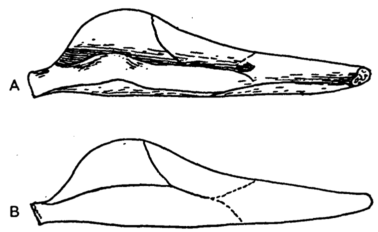

FIG. 7. Lower jaw. A, inner surface; B, outer surface. × 1

Prearticulars. — The prearticular extends forward on the inner side of the jaw. Just anterior to the articular it swells outward and the upper edge is separated, in the specimen, from the edge of the pterygoid by a thin line of matrix. The anterior end is overlapped for a short distance by the splenial.

Splenials. — The splenial is a thin, slender element which reaches almost to the symphasis, but does not take part in it.

Dentaries. — The dentary is the sole tooth-bearing element of the lower jaw. As shown in the transverse fracture, Figure 3, the teeth are confined to the outer edge. The palatal teeth pass inside the inner edge of the lower jaw. The fracture shows a considerable space for the Meckel's cartilage. The symphasis is strong.

THE AXIAL SKELETON

(Plate III, Fig. 4, and Text Figs. 8–12)

The first twelve vertebrae are in place with the ribs attached. The clavicles, probably the interclavicle, the scapula, humerus, radius and ulna, and part of the foot of the right side are in position; the coracoid, if preserved, is hidden by a mass of dermal scutes. The left humerus lay across the under side of the lower jaw and was removed to reveal more clearly the lower surface of the skull; the ulna lay above the humerus and the radius along the left maxillary just anterior to the orbit; portions of the left foot lay just upon the nose and were removed.

Posterior to the twelfth vertebra the column was folded upon itself and can be traced forward and backward through the nodule. The column was broken and disturbed in the sacral region; the sacral vertebrae are preserved, but no trace of the pelvis can be found except one pubis. The femur, tibia and fibula of the left side lie near their proper position in the folded vertebral column, on the under side of the nodule. No traces of the bones of the posterior foot were found unless some isolated podial elements may belong to them.

THE VERTEBRAL COLUMN

Atlas. — The atlas is represented by its disturbed elements which cannot be made out with entire certainty. Just anterior to the axis and lying upon it is the neural arch of the atlas showing

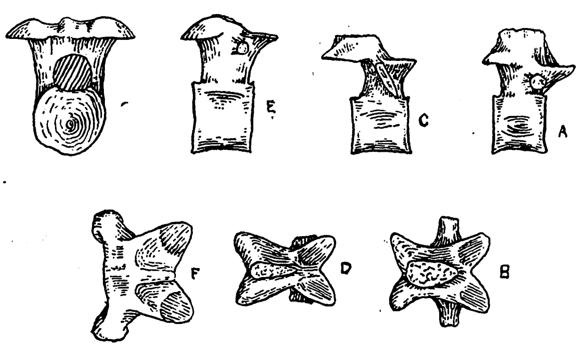

FIG. 8. Vertebrae. A, lateral view of axis; B, upper view of same; C, lateral view of twenty-third vertebra; D, upper view of same; E, lateral view of sacral vertebra; F, upper view of same; G, posterior view of same. All × 1

a low, almost rudimentary spine. On the right side is a small separate plate lying against the neural arch which may be a part of the atlas or may be a part of some other bone, possibly a part of two displaced caudal vertebrae which lie just below the axis-atlas. A rib of considerable size with distinct capitulum and tuberculum was attached to the atlas, but was necessarily destroyed in separating the pieces of the nodule to study the interior of the skull. Unfortunately the anterior face of the atlas cannot be made out, but there is nothing that could warrant the extremely broad face of the occipital condyle suggested by the position of the basioccipital and the exoccipitals; partly for this reason the exoccipitals have been rotated from their position in the specimen and the width of the condyle reduced in the restoration of the skull.

Axis (Text Figs. 8a–8b). — The axis is rather more elongate than the succeeding vertebrae with a neural spine of corresponding length but no greater height. The anterior and posterior zygapophyses are large and their faces, as in all the vertebrae, look directly up and down. The transverse process is well developed, rising from the anterior part of the neural arch and the centrum, entirely anterior to the neural spine. The attached rib is fairly long with well-developed capitulum and tuberculum and the distal part is expanded almost as much as in the succeeding vertebrae (see Fig. 9a).

Third to twelfth vertebrae. — These vertebrae are all very similar in form, so far as may be ascertained; the centra are covered by matrix. The neural spines are low and formed like that of the axis, but are shorter antero-posteriorly. The transverse processes occupy the same anterior position. The ribs are attached in position and show a gradual increase in length. The eighth rib still shows some expansion of the distal end, but beyond it the ribs are more slender and of equal diameter throughout. No trace of any intercentra can be found in this or any other part of the column.

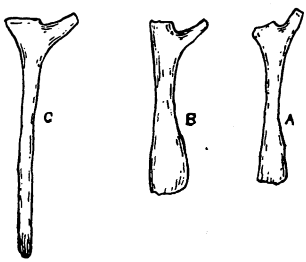

FIG. 9. Ribs. A, rib of the axis; B, rib of the fifth vertebra; C, rib of the twenty-third vertebra. All × 1

Thirteenth to twenty-third vertebrae. — At the thirteenth vertebra the column is sharply flexed upon itself and a series of eleven vertebrae, the thirteenth to the twenty-third, runs uninterruptedly back toward the head. This series differs little from the preceding series, but some vertebrae are revealed in section and some show the form of the centra. It is here that the characters described in the type specimen of *Ostodolepis* are apparent (see Figs. 8 a–8 g).

Twenty-fourth to twenty-eighth vertebrae. — Posterior to the twenty-third vertebra there is a break and then come three associated vertebrae with lower, broader arches much more closely resembling the typical vertebrae of the cotylosaurs and especially those of *Seymouria.* A second break is followed by two vertebrae in disturbed position; these have very broad and heavy neural arches and short, stout transverse processes; they can be only the sacral vertebrae, (see Figs. 8 e, f and g). The number, twenty-eight, of sacral and presacral vertebrae corresponds exactly with the number assigned by Williston to *Seymouria.*

Caudal vertebrae. — Beyond the sacrum in the sequence of vertebrae, but between it and the two previously described series of vertebrae in the nodule, there is a series of eight vertebrae sharply folded upon itself; these diminish gradually in size; the neural spines are thin and low, scarcely more than rudimentary ridges on the neural arches. The transverse processes are still in the anterior position, but are smaller and more slender, and the ribs (only one in position and visible) appear to be shorter and more sharply curved. This series is considered to be entirely caudal. Besides this series there are two caudal vertebrae immediately below the axis-atlas.

Clavicles. — The clavicles lie nearly in the normal position, slightly displaced to the right side, with the proximal ends slightly overlapping. The shaft of the bone is slender and bent near the center of the length, dividing it into a horizontal portion and a nearly vertical portion. The proximal ends are but little expanded and show slight or no rugosity.

Interclavicle. — The interclavicle is nearly covered by the matrix in such a position that it is impossible to clear it. The form cannot be made out exactly, but it can be seen that there is a broad proximal and a narrow posterior extension. If the bone is of the form suggested by the small portion exposed it is extraordinarily broad at the anterior end.

Cleithrum (?). — There is a small, irregular bit of bone in close association with the distal end of the right clavicle, but it is so imperfectly preserved that it cannot be made out clearly. This fragment is in the proper position for the cleithrum with relation to the clavicle and the scapula. If this determination is correct the lower end of the cleithrum was rather broad.

Scapula (Fig. 10). — The scapula of the right side is preserved complete or nearly so, and in its normal position with relation to the vertebrae, ribs and limb bones. The blade is rather narrow and elongate and the cotylar portion heavy.

Coracoid (?). — A mass of dermal scutes covers the spot where the coracoid should lie, if present, and could not be sacrificed.

Humerus (Plate I, Fig. 1, and Figs. 11a–11b). — The head of the humerus is broad with a prominent deltoid process. The

FIG. 10. Right scapula. × 1

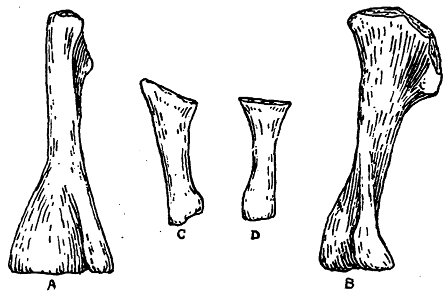

FIG. 11. A, posterior view of the humerus; B, anterior view of the same; C, ulna; D, radius. All of the right side. All × 1

shaft is contracted and angular in section rather than rounded. The lower end is turned almost at right angles to the upper end and there is no entepicondylar foramen. The articular surfaces are not well modeled, indicating the presence of considerable cartilage in the joints. The absence of the entepicondylar foramen and the presence of a considerable amount of cartilage in the articulations are indicative of amphibian affinities in the Permian vertebrates of North America.

Radius (Fig. 11d). — The radius is short, not quite half the length of the humerus, and stout.

Ulna (Fig. 11c). — The ulna is longer than the radius, stout and slightly curved. The olecranon process is poorly developed showing a poor articulation of the elbow joint.

Front foot. — A few small carpal bones, some metacarpals and phalanges, were found near the distal end of the right ulna and radius, but they are so disturbed in position that nothing of the form, number or arrangement can be made out, beyond the fact that the short and heavy metacarpals and phalanges indicate a short, stout foot such as would be expected from the character of the limb bones.

Pelvis. — Nothing of the pelvis was found except a single pubis in the proper position. The pubis is flat and oval with a large foramen. The pubis and ischium were, in all probability, flat and plate-like, as in all the more primitive reptiles.

Femur (Plate III, Fig. 4, and Text Fig. 12a). — The femur of the left side is preserved in close association with the tibia and fibula. The anterior face of the head is deeply concave with a distinct trochanter. The adductor ridge runs down the middle of the face instead of crossing diagonally to the outer edge of the lower end. This is amphibian rather than reptilian in character. The upper articular face is hidden by a mass of scutes, but the lower face shows the same lack of modeling as do the faces of the humerus.

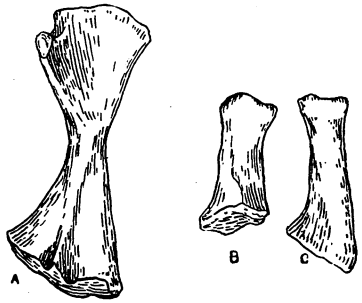

FIG. 12. A, Anterior view of femur; B, tibia; C, fibula. All of the left side. All × 1

Tibia and *fibula* (Text Figs. 12b–12c). — These are very short and stout. There are no certain indications of the posterior foot; some isolated foot bones may belong to the posterior foot.

THE DERMAL SCUTES

(Plate II, Figs. 4a–4b and 5, and Plate III, Figs. 1–3)

In the specimen the dermal scutes form a fairly solid mass on the ventral side of the thoracic and abdominal regions. It is evident that the abdominal surface was protected by closely set scutes which in the process of preservation have been packed one upon another (see Plate III, Fig. 1). As in the type specimen of *Ostodolepis* described by Williston, no trace of scutes was found on the dorsal surface. In no place has the complete form of a scute been made out, but it is evident that they were oval. Williston described them in the type specimen as approximately equal in longitudinal and transverse diameters; in this specimen they are distinctly elongate oval (see Plate II, Fig. 4a). Williston described the scutes as marked with concentric raised lines; the figures showing enlarged views of the scutes (Plate II, Fig. 5, and Plate III, Figs. 2–3) demonstrate that they are in no way like the "cycloid scales of fishes," but that they are made up of concentric rods or lamellae. This type of scute has not yet been recorded, so far as the author is aware. Credner in his description of *Discosaurus permianus*[3] notes that the discoid scutes are made of separate rods with cross connections and and cites their similarity to the scutes of living Gymnophiona, *Epicrum*, and to the Permian form, *Sparodus crassidens* of Fritsch. The scutes of *Ostodolepis* resemble most closely the scutes figured by Fritsch from *Sparodus*, in his *Fauna d. Gaskohle,* Band I, Plate 10, Figure 4.

CONCLUSION

Williston in his original description of *Ostodolepis* says: "The very short spines, the broad and flat zygapophyses and the strong rib attachments suggest a slender, lizard-like form for the living animal, one probably with long limbs and prehensile feet, cursorial or climbing in habit." It is evident from the character of the limbs and feet that Dr. Williston was very excusably misled in his interpretation of the habits and form of the animal by the

[3] *Zeitschrift d. Deut. Geol. Gesell.*, Jahrgang 1883.

slight amount of material at his disposal. So peculiar and aberrant is *Ostodolepis* that the author is unwilling to hazard more than a conjecture as to its habits. The strong limbs and feet, the low neural spines, the peculiar projecting rostrum and the large orbits are suggestive of fossorial habits and the sharp, conical teeth would be eminently fitted for the capture of worms and other soft-bodied forms.

The systematic position is even more puzzling. At present it can be safely placed only as an aberrant form of the Cotylosauria, though it could easily be placed in a separate new group, dependent entirely on individual opinion as to the value of its characters. Below is a list that indicates its peculiar assemblage of characters:

Characters indicating amphibian relationships
- Strong parasphenoid
- Wide interpterygoid space
- Course of adductor ridge on the femur
- Absence of entepicondylar foramen in the humerus
- Asymmetry of the skull bones
- Patch of spongy bone on the parasphenoid

Characters indicating reptilian relationships
- Single occipital condyle
- Well-developed basioccipital
- Pterygoids articulating with basisphenoid
- Intervertebral position of the capitulum of the rib
- Position of the paroccipital process
- Presence of a quadrate foramen
- Character of the teeth

Characters indicating specialization
- Elevation of the posterior portion of the skull
- Absence of a pineal foramen
- Large orbits
- Row of teeth on the palatine bone
- Flattened rostrum of the nose

DESCRIPTION OF PLATES

PLATE I

FIG. 1. Upper surface of the nodule showing the position of the specimen. × 1

FIG. 2. Upper surface of the skull. × 1

FIG. 3. Lower surface of the skull. × 1

PLATE II

FIG. 1. Right side of the skull. × 1

FIG. 2. Posterior surface of the skull. × 1

FIG. 3. a, median section of the skull, left side. × 1

b, median section of the skull, right side. × 1

FIG. 4. a, a group of dermal scutes. × 1.8

b, a second group of dermal scutes. × 1.8

FIG. 5. A portion of Figure 4 a, showing the parallel rods. × 14.5

PLATE III

FIG. 1. A surface showing edges of the dermal scutes. × 6

FIG. 2. A polished surface with edges of the dermal scutes, showing the parallel rods. × 6

FIG. 3. A portion of the same scutes shown in Figure 2. × 14.5

FIG. 4. Right femur, tibia and fibula. × 1

PLATE I

FIG. 1

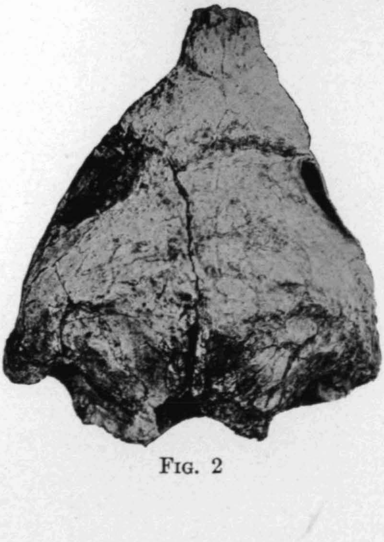

FIG. 2

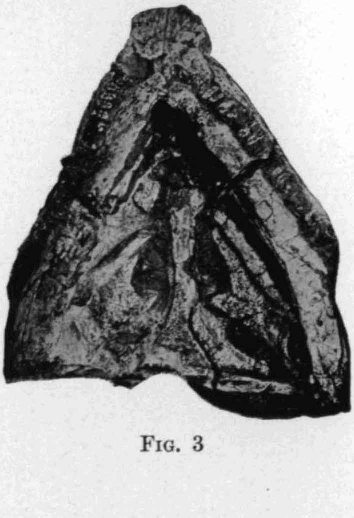

FIG. 3

PLATE II

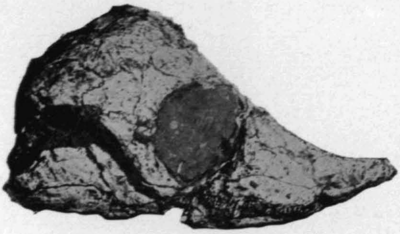

Fig. 1

Fig. 2

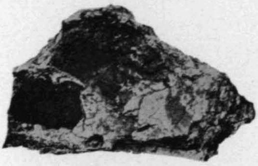

Fig. 3 a

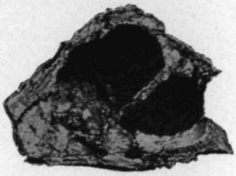

Fig. 3 b

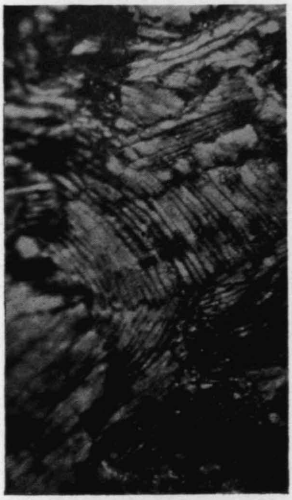

Fig. 5

Fig. 4 a

Fig. 4 b

PLATE III

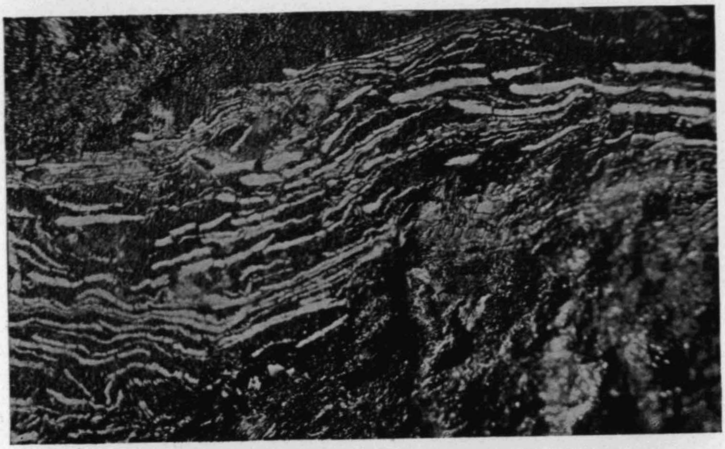

Fig. 1

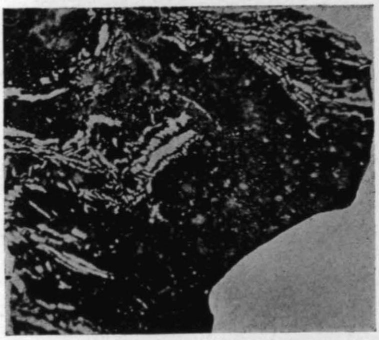

Fig. 2

Fig. 3

Fig. 4

(*Continued from inside of front cover*)

VOLUME III